UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MEMORANDUM

DATE: February 10, 2005

SUBJECT: Ellsworth Industrial Park (05B52A) - Screening Vapor Intrusion Analysis (1st iteration)

FROM: Ross del Rosario, RPM

TO: Addressees

Following our February 1, 2005 meeting regarding Ellsworth Industrial Park, I instructed one of our in-house risk assessors, Arunas Draugelis, to conduct a screening analysis on vapor intrusion (VI) at downgradient residential areas of the site. The analysis, in Excel spreadsheet, used the latest Johnson & Ettinger (J & E) Vapor Intrusion Model *for groundwater (Version 3.1, February 2004). Three (3) contaminants of concern were* evaluated: 1) Trichlorethene (TCE) 2) Perchloroethene (PCE) and 3) 1,1,1 Trichloroethane (1,1,1 TCA). The results of the analysis, based on the highest values observed for these contaminants, are as follows:

1. *Potential incremental risk from VI to indoor air associated with* **TCE** was **7.8 x 10^{-6}**;

2. The corresponding value for **PCE** was **5.2 x 10^{-7}**; and

3. For **1,1,1 TCA**, no risk value was given by the analysis. The IRIS database designated this compound as a non-carcinogen (although the drinking water tables rated this compound as a "possible human carcinogen"). A hazard index (**HI**) of **4.9 x 10^{-5}** was calculated, significantly less than the value of 1 that we use for reference.

Conclusion: Based on the results above, the potential incremental cancer risks associated with TCE and PCE in the groundwater below the homes is expected to be negligible. For reference, the draft vapor intrusion guidance (2002) recommended using **1 x 10^{-5}** as the basis for taking follow-up action on VI. Consequently, further action on VI is not warranted at this point. Further VI investigation is already planned as part of the future groundwater operable unit at the site. Similarly, in 2002, IEPA concluded (through its contractor, Parsons) that VI risks for the neighboring Lockformer site in Lisle, Illinois were negligible (see attached).

Qualifier(s): The data used in the calculation is rather limited and the site geology is not fully defined. A default value was used in cases where such site-specific data (e.g., porosity, temperature, etc.) was not available. While the use of default values is allowed in the analysis, using site-specific data is preferable.

Data Input: The following assumptions were made in the analysis:

1. The analysis used the highest concentration found for each of the above contaminants at the residential wells sampled in 2001-2002 – 14 ug/l for PCE, 16.6 ug/l for TCE, and 6.3 ug/l for TCA. (**Note: The specific identities and addresses of these homes are still considered confidential and should be handled accordingly**);

2. Data from the southernmost monitoring well network at the industrial park (BD-16D through BD-18D), located just north of the downgradient homes, indicated relatively similar concentrations for TCE, PCE, and 1,1,1 TCA (see attached). Using these values, incremental cancer risks from VI for TCE and PCE were calculated to be **7.2×10^{-6}** and **1.2×10^{-8}**, respectively (see attached). These figures compare favorably with the calculations made for the residential wells using the highest concentrations found for these contaminants;

3. A depth to water value of 100 feet was used after averaging the actual values found in previous surveys (see attached). It is noted that, while there may be shallower aquifers present in the residential area, the presence of the thick clay layer and relatively low levels of TCE and PCE would be unlikely to change the conclusion reached above;

4. The analysis took into account a 50-60 feet-thick clay layer overlying the water table in the residential area. This information was taken from drilling/boring log data available to this office. For the industrial park, boring logs from the monitoring wells described a 25-35 foot clay layer overlying a 10-foot sand and gravel layer; and

5. The analysis assumed that a silty clay layer lay directly above the residential wells, with a corresponding porosity value (0.43). If the actual stratigraphy is different, the porosity would also change and could affect the results numerically. As with Item #3 above, the authors of this analysis don't believe such a change will fundamentally alter the conclusion.

If there are any questions related to this matter, please contact me at (312) 886-6195.

Attachments

Addressees: Rick Karl
Wendy Carney
Jim Mayka
Rosita Clarke-Moreno
Tom Krueger
Fred Nika, IEPA
Arunas Draugelis

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF

MEMORANDUM

DATE: February 10, 2005

SUBJECT: Screening Vapor Intrusion Analysis – Ellsworth Industrial Park, Downers Grove, IL (Site ID B52A)

FROM: Arunas K. Draugelis, Toxicologist AKD

TO: Ross del Rosario, RPM

As per you Memorandum of February 2, 2005, and February 10, 2005, I used the information and data supplied to screen the effects from TCE, PCE and 1,1,1, TCA for vapor intrusion into residential homes. I used the Johnson and Ettinger (J&E) Vapor Intrusion Model, Ground Water-Advanced Version 3.1; 02/04 and have attached the Data Entry Sheets and Results Sheets for TCE, PCE and 1,1,1-TCA.

The results seem to indicate that the incremental risk from these chemicals through the vapor intrusion pathway would be negligible and would not warrant any action from this pathway.

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	1.66E+01	Trichloroethylene

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
			Totals must add up to value of L_{WT} (cell G28)							
10	200	3200	200	1500	1500	C	SC			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
	1.50	0.430	0.18		1.5	0.43	0.215		1.5	0.43	0.197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based groundwater concentration	

END

A-1

RESULTS SHEET 79016/TCE

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	1.47E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
7.8E-06	4.1E-03

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

B-1

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
127184	1 40E+01	Tetrachloroethylene

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
			Totals must add up to value of L_{WT} (cell G28)							
10	200	3200	200	1500	1500	C	SC			1 00E-08

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
	1 50	0 430	0 18		1.5	0 43	0.215		1.5	0.43	0 197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0 1	0 25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

B-1

RESULTS SHEET 127184 / PCE

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
5.2E-07	3.4E-04

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

C -1

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
71556	6 30E+00	1,1,1-Trichloroethane

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	200	3200	200	1500	1500	C	SC			1 00E-08

Thickness columns: Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
	1 50	0.430	0 18		1 5	0 43	0.215		1.5	0.43	0.197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0 1	0 25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

C-1

RESULTS SHEET 71556 / 1,1,1-TCA

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.33E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	4.9E-05

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

TCE - A-1

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	4 00E+01	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	200	1300	200	1100	300	B	C	SCL		

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
SCL	1 63	0 384	0 146	C	1 43	0.459	0 215	SC	1 63	0 385	0 197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0 25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

B TCE-A-2

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.47E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
7.2E-06	3.8E-03

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: *Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.*

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

B PCE-A-1

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
127184	9.60E-01	Tetrachloroethylene

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	200	1300	200	1100	300	B	C	SCL		

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SCL	1.63	0.384	0.146	C	1.43	0.459	0.215	SC	1.63	0.385	0.197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration

END

B PCE-A-2

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.2E-08	7.7E-06

MESSAGE AND ERROR SUMMARY BELOW. (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

B 1-1-1-TCA - A-1

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
71556	1 30E+00	1,1,1-Trichloroethane

MORE ↓

ENTER Average soil/groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	200	1300	200	1100	300	B	C	SCL		

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SCL	1 63	0 384	0 146	C	1 43	0 459	0 215	SC	1 63	0 385	0 197

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0 1	0 25	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

B 1.1.1-TCA- A-2

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	NA	NA	1.33E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	3.2E-06

MESSAGE AND ERROR SUMMARY BELOW (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MEMORANDUM

DATE: February 2, 2005

SUBJECT: Request for Screening Vapor Intrusion Analysis - Ellsworth Industrial Park, Downers Grove, IL (Site ID B52A)

FROM: Ross del Rosario, RPM

TO: *Arunas Draugelis, Toxicologist*

I am requesting a screening analysis for potential vapor intrusion of contaminants from monitoring and residential wells around the Ellsworth Industrial Park, per our discussion yesterday. Attached you will find pertinent data to assist you in completing the analysis. In addition to the attached, please use the following data as part of your calculation:

Residential Well Data:	Hydraulic Conductivity:	GW Flow:
TCE - 16.6 ug/L PCE - 14.0 ug/L 1,1,1 TCA - 6.3 ug/L	0.0016 ft/ft	South-Southeast

I would like you to provide me with a transmittal memo containing the following information:

1. Printouts/output from modeling exercise you performed using both the monitoring well and residential well data, using the calculated hydraulic conductivity and geological data provided;

2. Your evaluation of the output data. To the extent you are able to, please elaborate if vapor intrusion is a real or potential problem at this location;

3. Recommendation(s) or conclusion(s), if any, you may have after evaluating the data.

Your assistance on this matter is greatly appreciated. Due to importance of this analysis on the project, I would like to have your transmittal memo completed no later than February 8, 2005. Thank you.

Table 4-4 (Continued)
AREA 7
Tricon Property

(All units in ug/L)

Sample Identification	BD-16(D)	BD-17(D)	BD-18(D)
Depth (feet)	74-84	81-91	81-91
Date Sampled	6/19/02	6/20/02	6/20/02
Parameter			
1,1,1 TCA	1.3	---	---
1,1- DCA	---	---	---
1,1 - DCE	---	---	---
cis -- 1,2 DCE	---	3.2	---
trans -- 1,2 DCE	---	---	---
Tetrachloroethene (PCE)	0.69 J	0.96 J	---
Trichloroethene (TCE)	40	13	---
Acetone	---	---	---
2--Butanone	---	---	---
Toluene	---	---	---
1,24- Trimethylbenzene	---	---	---
Ethyl Benzene	---	---	---
m/p xylene	---	---	---
o-xylene	---	---	---
Dichlorodifluoromethane	---	---	---
Iodomethane	---	---	---
Naphthalene	---	---	---

--- - not detected.

Bob Kay/R5/USEPA/US
02/01/2005 04:43 PM

To ROSAURO DELROSARIO/R5/USEPA/US@EPA
cc
bcc
Subject Ellsworth request

Ross--I've looked over some the well logs for the residential wells in the residential area around the Ellsworth site and the geology, in a VERY general way, looks as follows (all depths in feet from ground surface)

0-1 topsoil
1-60 clay
60-120 sand and gravel or clay
120 and beyond bedrock

if you figure the average basement has a depth of about 8-10 feet, that means in most of this area there's something like 50 ft or so of low-permeability material between the VOCs dissolved in the ground water and the bottom of someone's basement.

Table 2. Well information and water levels in select residential-supply wells in the vicinity of the Ellsworth Industrial Site, Downer's Grove, Illinois, September 23-24, 2003. [?-unknown; Bold denotes uncertain of accuracy; BR, bedrock aquifer; >, greater than; <, less than]

			September 22-23, 2003		October 12, 2004			
Well name	Measuring-Point Altitude (feet above sea level)	Geophysical Logs ?	Depth to Water (feet)	Water-Level Altitude (feet above sea level)	Depth to Water (feet)	Water-Level Altitude (feet above sea level)	Depth of Open Interval (feet)	Change (feet)
RW1	744.61		98.10	646.51	97.15	647.46	115-140	0.95
RW2	760.20		112.25	647.95	111.50	648.70	128-180	0.75
RW3	711.79		66.10	645.69	65.73	646.06	?	0.37
RW4	747.44		101.19	646.25	98.66	648.78	?-240	2.53
RW5	770.80		126.27	644.53	-	-	?	-
RW6	717.35		65.90	651.45	65.28	652.07	106-185	0.62
RW7	773.09		129.20	643.89	125.25	647.84	?	3.95
RW8	739.92		92.00	647.92	91.15	648.77	?	0.85
RW9	730.39		82.19	648.20	81.35	649.04	?	0.84
RW10	745.55		101.39	644.16	98.25	647.30	?	3.14
RW11	747.55		100.75	646.80	-	-	?	-
RW12	738.36		90.62	647.74	88.15	650.21	?	2.47
RW13	745.57		**>101**	**<645.57**	98.62	646.95	?	-
RW14	744.91		99.70	645.21	-	-	?	-
RW15	743.58		95.20	648.38	94.45	649.13	?	0.75
RW16	745.20		101.60	643.60	97.75	647.45	110-160	3.85
RW17	767.77		119.40	648.37	118.70	649.07	120-205	0.70
RW18	738.00		89.66	648.34	88.82	649.18	102-185	0.84
RW19	760.09		**116.62**	**643.47**	111.38	648.71	100-?	5.24
RW20	744.19		97.67	646.52	96.95	647.24	115-140	0.72
RW21	752.61		**99.80**	**652.81**	105.14	647.47	111-175	-5.34
RW22	765.09		115.09	650.00	116.45	648.64	110-190	-1.36
RW23	765.61		117.33	648.28	116.60	649.01	120-205	0.73
RW24	738.57		93.05	645.52	91.10	647.47	120-140	1.95
RW25	759.55		111.50	648.05	-	-	130-175	-
RW26	757.15		108.98	648.17	108.30	648.85	120-170	0.68

RW27	748.39	104.10	644.29	99.85	648.54	126-185	4.25
RW28	763.47	120.05	643.42	115.75	647.72	126-205	4.30
RW29	754.57	112.74	641.83	**110.98**	643.59	144-185	1.76
RW30	742.81	94.50	648.31	-	-	116-175	-
RW31	749.00	104.90	644.10	-	-	128-171	-
RW32	757.86	112.85	645.01	-	-	105-150	-
RW33	763.32	**121**	**642.32**	114.55	648.77	120-205	6.45
RW34	731.09	86.20	644.89	-	-	?	-
RW35	755.89	108.31	647.58	107.57	648.32	125-163	0.74

Table 1. Well information and water-level data from select monitoring wells, Ellsworth Industrial site, Downers Grove, Illinois. [NT, not taken; -, unavailable; Bold denotes uncertain value]

					September 23, 2003		October 12, 2004	
Well	Geologic Deposit Monitored by Well	Measuring Point Altitude (feet above sea level)	Depth of Screen Interval (feet)	Altitude of Bottom of Open Interval (feet above sea level)	Depth to Water (feet)	Water-Level Altitude (feet above sea level)	Depth to Water (feet)	Water-Level Altitude (feet above sea level)
BD-1I	Drift	696.56	27-37	662	25.12	671.44	-	-
BD-1D	Bedrock	696.25	60-70	626	46.62	649.63	-	-
BD 4I	Drift	701.65	47-57	**645**	43.01	658.64	**43.52**	658.13
BD 4D	Bedrock	701.83	71-81	620	52.48	649.35	**51.95**	649.88
BD 5I	Drift	689.05	37-47	**642**	32.52	656.53	32.15	656.90
BD 5D	Bedrock	689.31	54-64	622	39.38	649.93	38.67	650.64
BD 6I	Drift	692.91	45-50	**643**	43.01	649.9	42.34	650.57
BD 6D	Bedrock	692.97	64-74	619	43.29	649.68	42.63	650.34
BD 7I	Drift	690.02	36-46	**644**	32.96	657.06	32.59	657.43
BD 7D	Bedrock	689.64	60-70	620	40.37	649.27	39.42	650.22
BD 8I	Drift	689.86	35-45	**645**	39.19	650.67	38.71	651.15
BD 8D	Bedrock	690.00	68-78	610	40.22	649.78	39.57	650.43
BD 9I	Drift	715.19	37-42	673	dry		45.30	669.89
BD 9D	Bedrock	715.12	79-89	623	63.91	651.21	63.18	651.94
BD 10D	Bedrock	717.35	79-89	628	66.26	651.09	65.47	651.88
BD-11D	Bedrock	703.69	94-104	600	-	-	-	-
BD 12D	Bedrock	700.30	78-88	612	51.20	649.1	50.60	649.70
BD 13I	Drift	701.46	41-46*	634	**7.44**	694.02	-	-
BD 13D	Bedrock	701.46	79-89	612	52.56	648.9	51.84	649.62
BD 14I	Drift	698.73	42-47	651	dry	<651	**46.80**	651.93
BD 14D	Bedrock	699.28	73-83	616	48.39	650.89	47.65	651.63
BD 16D	Bedrock	705.36	74-84	621	56.90	648.46	56.15	649.21
SB 17I	Drift	694.96	35-45	650	*37.85*	657.11	*63.09*	631.87
BD 18D	Bedrock	706.85	81-91	616	**63.80**	643.05	57.26	649.59
OV6I	Drift	693.60	40-50	**644**	-	-	43.25	650.35
BD-15I	drift	690.22	35-45	**645**	-	-	-	-
DG-1I	top bedrock	688.31	20-30	668	-	-	28.41	659.90
DG-1D	top bedrock	686.94	35-45	**642**	-	-	27.21	659.73
DG-2I	top bedrock	698.62	47-57	**641**	-	-	42.17	656.45

DG-3I	top bedrock	701.56	50-60	**641**	-	-	**48.89**	652.67
DG-4I	top bedrock	703.77	50-60	**643**	-	-	53.41	650.36
DG-5I	top bedrock	694.34	50-60	634	-	-	44.20	650.14
DG-6I	top bedrock	697.93	50-60	638	-	-	46.67	651.26
DG-15I	*mid-drift*	702.92	55-65	637	-	-		702.92
SB-15I	top bedrock	**702.09**	32-37	665	-	-	34.34	667.75
LD-1I		708.03	54-64	**644**	-	-	58.22	649.81

Post-it® Fax Note 7671	Date 2/4/2005 # of pages ▶ 15
To Ross Delrossi	From Tracy Hurley
Co./Dept.	Co.
Phone #	Phone # 217-524-4034
Fax # 312-886-4071	Fax #

PARSONS

Parsons Engineering Science, Inc. · A Unit of Parsons Infrast
Oakmont Plaza Drive · Suite 420 · Westmont, Illinois 60559 ·

March 21, 2002

Mr. Stan Komperda
Project Manager
Illinois Environmental Protection Agency
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794-9276

Re: Groundwater/Enclosed Space Inhalation Risk Evaluation
Lockformer Site, Lisle, Illinois

Dear Mr. Komperda:

In response to your recent comments, Parsons is pleased to provide the following summary of our evaluation of the inhalation risk posed by groundwater containing dissolved concentrations of trichloroethene (TCE) in the vicinity of the Lockformer site in Lisle, Illinois.

SUMMARY OF ANALYSIS

Parsons performed inhalation risk evaluation using the ASTM 1739-95 Risk-Based Corrective Action standard, Section X2.5, *Ground Water – Inhalation of Enclosed-Space (Indoor) Vapors*. This methodology was used to estimate the inhalation risk in the basement of a theoretical private residence located directly above a groundwater plume of TCE in a subsurface lithology consistent with that of the Lockformer site in Lisle, Illinois. Attachment A includes the relevant pages from the ASTM standard that were used in evaluating this risk. Attachment B contains the specific work sheets developed by Parsons, which include all of the assumed input parameters used in this evaluation and the referenced source for each parameter.

A detailed description of the calculation methodology is included below. In summary, the ASTM analysis indicates that at the maximum concentrations at which TCE has been detected in a private well in the vicinity of the Lockformer site (~20 ppb), the contribution to inhalation cancer risk is less than 1×10^{-6}. Specifically, our analysis was performed using three assumed groundwater concentrations for TCE: 10 parts per billion (ppb), 50 ppb, and 1,000 ppb (or 1 part per million, ppm). The table below shows the resulting inhalation cancer risk posed by each of these assumed concentrations:

TCE Concentration (ug/l)	Inhalation Cancer Risk
10	2.03×10^{-7}
50	1.02×10^{-6}
1,000	2.03×10^{-5}

RECEIVED
MAR 25 2002
IEPA
Environmental Policy & Science

LIMITATIONS OF ANALYTICAL METHODOLOGY

Having supplied the results of our analysis above, we feel it is also important to point out the significant limitations of the analytical method described in the ASTM standard. A quick perusal of the attached worksheets shows the significant number of assumptions that need to be made in order to complete this analysis. The geometry of the lithology, the depth at which the TCE plume is traveling laterally, and the specific geometry of the foundation cracks through which TCE vapors are assumed to enter the indoor space all factor significantly into the results of this analysis; none of these input parameters to the analytical model are known with any degree of certainty for the Lockformer site.

For reasons explained in more detail in the following section, the analysis is particularly sensitive to the thickness of the capillary fringe layer, or in the particular case of the Lockformer site, to the thickness of uncontaminated water that may exist above the horizon at which the TCE plume may be traveling laterally in bedrock. (This sensitivity is related to the fact that any thickness of uncontaminated groundwater will significantly inhibit the diffusion of TCE in an upward direction). An illustration of this model sensitivity is shown in the table below. Three different thicknesses of an uncontaminated, inhibiting groundwater layer were assumed. The corresponding TCE source concentration related to an inhalation risk of 10^{-6} was then calculated. As shown by the table below; the thickness of this groundwater layer is roughly proportional to the source TCE concentration corresponding to a risk level of 10^{-6}.

Assumed Thickness of Inhibiting Groundwater Layer (ft)	TCE Concentration Corresponding to 10^{-6} Inhalation Risk (ug/l)
1	10.6
5	49.2
10	97.5

Because the inhalation risk level varies so significantly with the variation of the inhibiting groundwater layer (an unknown parameter at the Lockformer site), it is important to view the results of our analysis through the context of this limitation. Still, the variation in risk level varies primarily in a conservative manner; i.e., the risk level is likely less than 10^{-6} in the vicinity of the Lockformer site, given all of the currently available information.

DETAILED DISCUSSION OF ANALYSIS

The chemical characteristics of TCE used in the analysis were obtained from Part 742, Illinois Administrative Code. Most of remaining input parameters were obtained directly from the ASTM standard. The inhalation cancer slope factor for TCE was provided by the IEPA.

The site-specific parameters used in the calculations are depth to groundwater, thickness of the capillary fringe layer, and the thickness of the vadose zone. In our analysis, the air and water volumetric content of the pore space within the capillary fringe layer were modified to reflect the most likely transport mechanisms of the TCE plume at the Lockformer site.

Figure 1 in Attachment A shows modeling assumptions regarding the definition of depth to groundwater, thickness of the capillary fringe, and the thickness of the vadose zone. It is assumed in this model that the constant source of dissolved contamination is already present at the top of the water table and that no diffusion transport is needed for contamination to reach the top of groundwater table from this constant source.

Transport characteristics through soil and the capillary fringe zone depend on the thickness of the zone, the air and water volumetric content of the pore space within the zone, and the compound diffusivity through air and water. The effective diffusion coefficient is a measure for the combined effect of these factors. The air diffusivity coefficient for TCE is several orders of magnitude higher than the corresponding water diffusivity coefficient.

For that reason, the effective diffusion through the capillary fringe zone (containing mostly water) is significantly lower than the effective diffusion coefficient for the vadose zone (containing mostly air). The resulting overall effective diffusion coefficient (calculated for the entire zone over which diffusion takes place) depends most significantly on the thickness of the layer with the smallest diffusion coefficient (the capillary fringe layer). Accordingly, the thickness of this capillary fringe layer is a much more significant input parameter than the thickness of the vadose zone through which the TCE must diffuse.

For the purposes of this analysis, Parsons assumed that the TCE plume has traveled laterally through a network of bedrock fractures to the off-site residential neighborhood, and that at least some of the groundwater in the saturated zone above the bedrock (and beneath the private residences) has not been affected (as would be the case if the release of TCE had originated from directly above). This conclusion has yet to be proven with actual data, but is a reasonable assumption given the likely transport mechanisms of the off-site TCE plume.

The attached evaluation assumes that the constant source of dissolved contamination in bedrock is approximately 5 feet below the groundwater surface. Based on currently available data, this is a conservative assumption (i.e., the thickness of uncontaminated groundwater may be more than 5 feet). Parsons treated this 5-foot layer as a capillary fringe layer by adjusting the volumetric content of soil vapor for this layer to zero to reflect the fact that the entire 5-foot thickness is completely saturated with water.

SUMMARY OF ANALYSIS

Overall, our analysis of the available data using the best available models leads us to conclude that TCE groundwater concentrations above 50 ppb at the Lockformer site could potentially contribute to an inhalation cancer risk greater than 1×10^{-6}; however, the highest groundwater TCE concentration actually observed in the vicinity of the Lockformer site is less than this level (~20 ppb). It should also be noted that the limitations of the calculation methodology should not be ignored; the results of this analysis are very sensitive to changes in input parameters, and our conclusion should only be viewed as a preliminary conclusion based upon the available data. The only way to confidently and quantifiably determine the inhalation risk in the private residences would be through a systematic and empirical air sampling program in the vicinity of the Lockformer site.

We appreciate the opportunity to provide you with this analysis. Please call Mr. Sasa Jazic at any time if you have questions related to this letter, or should require any other additional assistance.

Sincerely,

PARSONS CORPORATION

Sasa Jazic
Project Engineer

Richard M. Frendt, P.E.
Technical Director

SJ/RF:ko
enclosures

cc: Stan Black, IEPA
Maggie Carson, IEPA
Tracy Hurley, IEPA
Michelle Ryan, IEPA
Kendra Pohn, AGO
Howard Chinn, AGO
File: 739542

ATTACHMENT A

ASTM 1739-95

Ground Water – Inhalation of Enclosed-Space (Indoor) Vapors

tions and parameters used to prepare the example look-up Table X2.1. The basis for each of these equations is discussed in X2.2 through X2.10.

X2.2 *Air—Inhalation of Vapors (Outdoors/Indoors)*—In this case chemical intake results from the inhalation of vapors. It is assumed that vapor concentrations remain constant over the duration of exposure, and all inhaled chemicals are absorbed. Equations appearing in Tables X2.2 and X2.3 for estimating RBSLs for vapor concentrations in the breathing zone follow guidance given in Ref (26). Should the calculated RBSL exceed the saturated vapor concentration for any individual component, "$>P_{vap}$" is entered in the table to indicate that the selected risk level or hazard quotient cannot be reached or exceeded for that compound and the specified exposure scenario.

X2.3 *Ground Water—Ingestion of Ground Water*—In this case chemical intake results from ingestion of ground water. It is assumed that the dissolved hydrocarbon concentrations remain constant over the duration of exposure. Equations appearing in Tables X2.2 and X2.3 for estimating RBSLs for drinking water concentrations follow guidance given in Ref (26) for ingestion of chemicals in drinking water. Should the calculated RBSL exceed the pure component solubility for any individual component, ">S" is entered in the table to indicate that the selected risk level or hazard quotient cannot be reached or exceeded for that compound and the specified exposure scenario (unless free-phase product is mixed with the ingested water).

TABLE X2.2 Equations Used to Develop Example Tier 1 Risk-Based Screening Level (RBSLs) Appearing in "Look-Up" Table X2.1—Carcinogenic Effects[A]

NOTE—See Tables X2.4 through X2.7 for definition of parameters.

Medium	Exposure Route	Risk-Based Screening Level (RBSL)
Air	inhalation[B]	$RBSL_{air}\left[\frac{\mu g}{m^3\text{-}air}\right] = \frac{TR \times BW \times AT_c \times 365\,\frac{days}{years} \times 10^3\,\frac{\mu g}{mg}}{SF_i \times IR_{air} \times EF \times ED}$
Ground water	ingestion (potable ground water supply only)[B]	$RBSL_w\left[\frac{mg}{L\text{-}H_2O}\right] = \frac{TR \times BW \times AT_c \times 365\,\frac{days}{years}}{SF_o \times IR_w \times EF \times ED}$
Ground water[C]	enclosed-space (indoor) vapor inhalation[D]	$RBSL_w\left[\frac{mg}{L\text{-}H_2O}\right] = \frac{RBSL_{air}\left[\frac{\mu g}{m^3\text{-}air}\right]}{VF_{wesp}} \times 10^{-3}\,\frac{mg}{\mu g}$
Ground water[C]	ambient (outdoor) vapor inhalation[D]	$RBSL_w\left[\frac{mg}{L\text{-}H_2O}\right] = \frac{RBSL_{air}\left[\frac{\mu g}{m^3\text{-}air}\right]}{VF_{wamb}} \times 10^{-3}\,\frac{mg}{\mu g}$
Surficial soil	ingestion of soil, inhalation of vapors and particulates, and dermal contact[B]	$RBSL_s\left[\frac{\mu g}{kg\text{-}soil}\right] = \frac{TR \times BW \times AT_c \times 365\,\frac{days}{years}}{EF \times ED\left[\left(SF_o \times 10^{-6}\,\frac{kg}{mg} \times (IR_{soil} \times RAF_o + SA \times M \times RAF_d)\right) + (SF_i \times IR_{air} \times (VF_{ss} + VF_p))\right]}$ For surficial and excavated soils (0 to 1 m)
Subsurface soil[C]	ambient (outdoor) vapor inhalation[D]	$RBSL_s\left[\frac{mg}{kg\text{-}soil}\right] = \frac{RBSL_{air}\left[\frac{\mu g}{m^3\text{-}air}\right]}{VF_{samb}} \times 10^{-3}\,\frac{mg}{\mu g}$
Subsurface soil[C]	enclosed space (indoor) vapor inhalation[D]	$RBSL_s\left[\frac{mg}{kg\text{-}soil}\right] = \frac{RBSL_{air}\left[\frac{\mu g}{m^3\text{-}air}\right]}{VF_{sesp}} \times 10^{-3}\,\frac{mg}{\mu g}$
Subsurface soil[C]	leaching to ground water[D]	$RBSL_s\left[\frac{mg}{kg\text{-}soil}\right] = \frac{RBSL_w\left[\frac{mg}{L\text{-}H_2O}\right]}{LF_{sw}}$

[A] Note that all RBSL values should be compared with thermodynamic partitioning limits, such as solubility levels, maximum vapor concentrations, and so forth. If a RBSL exceeds the relevant partitioning limit, this is an indication that the selected risk or hazard level will never be reached or exceeded for that chemical and the selected exposure scenario.

[B] Screening levels for these media based on other considerations (for example, aesthetic, background levels, environmental resource protection, and so forth) can be derived with these equations by substituting the selected target level for $RBSL_{air}$ or $RBSL_w$ appearing in these equations.

[C] These equations are based on Ref (26).

[D] These equations simply define the "cross-media partitioning factors," VF_{ij} and LF_{sw}.

TABLE X2.4 Exposure Parameters Appearing in Tables X2.2 and X2.3

Parameters	Definitions, Units	Residential	Commercial/Industrial
AT_c	averaging time for carcinogens, years	70 years	70 years[A]
AT_n	averaging time for noncarcinogens, years	30 years	25 years[A]
BW	adult body weight, kg	70 kg	70 kg[A]
ED	exposure duration, years	30 years	25 years[A]
EF	exposure frequency, days/years	350 days/year	250 days/year[A]
IR_{soil}	soil ingestion rate, mg/day	100 mg/day	50 mg/day[A]
IR_{air}-indoor	daily indoor inhalation rate, m^3/day	15 m^3/day	20 m^3/day[A]
IR_{air}-outdoor	daily outdoor inhalation rate, m^3/day	20 m^3/day	20 m^3/day[A]
IR_w	daily water ingestion rate, L/day	2 L/day	1 L/day[A]
LF_{sw}	leaching factor, (mg/L-H_2O)/(mg/kg-soil)—see Table X2.5	chemical-specific	chemical-specific
M	soil to skin adherence factor, mg/cm^2	0.5	0.5[B]
RAF_d	dermal relative absorption factor, volatiles/PAHs	0.5/0.05	0.5/0.05[B]
RAF_o	oral relative absorption factor	1.0	1.0
$RBSL_i$	risk-based screening level for media i, mg/kg-soil, mg/L-H_2O, or µg/m^3-air	chemical-, media-, and exposure route-specific	chemical-, media-, and exposure route-specific
RfD_i	inhalation chronic reference dose, mg/kg-day	chemical-specific	chemical-specific
RfD_o	oral chronic reference dose, mg/kg-day	chemical-specific	chemical-specific
SA	skin surface area, cm^2/day	3160	3160[A]
SF_i	inhalation cancer slope factor, $(mg/kg\text{-}day)^{-1}$	chemical-specific	chemical-specific
SF_o	oral cancer slope factor, $(mg/kg\text{-}day)^{-1}$	chemical-specific	chemical-specific
THQ	target hazard quotient for individual constituents, unitless	1.0	1.0
TR	target excess individual lifetime cancer risk, unitless	for example, 10^{-6} or 10^{-4}	for example, 10^{-6} or 10^{-4}
VF_i	volatilization factor, (mg/m^3-air)/(mg/kg-soil) or (mg/m^3-air)/(mg/L-H_2O)—see Table X2.5	chemical- and media-specific	chemical- and media-specific

[A] See Ref (27).
[B] See Ref (28)

surface,

X2.4.2.4 No loss of chemical as it diffuses towards ground surface (that is, no biodegradation), and

X2.4.2.5 Steady well-mixed atmospheric dispersion of the emanating vapors within the breathing zone as modeled by a "box model" for air dispersion.

X2.4.3 Should the calculated $RBSL_w$ exceed the pure component solubility for any individual component, ">S" is entered in the table to indicate that the selected risk level or hazard quotient cannot be reached or exceeded for that compound and the specified exposure scenario.

X2.5 *Ground Water—Inhalation of Enclosed-Space (Indoor) Vapors:*

X2.5.1 In this case chemical intake results from the inhalation of vapors in enclosed spaces. The chemical vapors originate from dissolved hydrocarbons in ground water located some distance below ground surface. Here the goal is to determine the dissolved hydrocarbon RBSL that corresponds to the target RBSL for vapors in the breathing zone, as given in Tables X2.2 and X2.3. If the selected target vapor concentration is some value other than the RBSL for inhalation (that is, odor threshold or ecological criterion), this value can be substituted for the $RBSL_{air}$ parameter appearing in the equations given in Tables X2.2 and X2.3.

X2.5.2 A conceptual model for the transport of chemicals from ground water to indoor air is depicted in Fig. X2.2. For simplicity, the relationship between enclosed-space air and dissolved ground water concentrations is represented in Tables X2.2 and X2.3 by the "volatilization factor" VF_{wesp} [(mg/m^3-air)/(mg/L-H_2O)] defined in Table X2.5. It is based on the following assumptions:

X2.5.2.1 A constant dissolved chemical concentration in ground water,

X2.5.2.2 Equilibrium partitioning between dissolved chemicals in ground water and chemical vapors at the ground water table,

X2.5.2.3 Steady-state vapor- and liquid-phase diffusion through the capillary fringe, vadose zone, and foundation cracks,

X2.5.2.4 No loss of chemical as it diffuses towards ground surface (that is, no biodegradation), and

X2.5.2.5 Steady, well-mixed atmospheric dispersion of the emanating vapors within the enclosed space, where the convective transport into the building through foundation cracks or openings is negligible in comparison with diffusive transport.

X2.5.3 Should the calculated $RBSL_w$ exceed the pure component solubility for any individual component, ">S" is entered in the table to indicate that the selected risk level or hazard quotient cannot be reached or exceeded for that compound and the specified exposure scenario.

X2.6 *Surficial Soils—Ingestion, Dermal Contact, and Vapor and Particulate Inhalation:*

X2.6.1 In this case it is assumed that chemical intake results from a combination of intake routes, including: ingestion, dermal absorption, and inhalation of both particulates and vapors emanating from surficial soil.

X2.6.2 Equations used to estimate intake resulting from ingestion follow guidance given in Ref (26) for ingestion of chemicals in soil. For this route, it has been assumed that surficial soil chemical concentrations and intake rates remain constant over the exposure duration.

X2.6.3 Equations used to estimate intake resulting from dermal absorption follow guidance given in Ref (26) for dermal contact with chemicals in soil. For this route, it has been assumed that surficial soil chemical concentrations and absorption rates remain constant over the exposure duration.

X2.6.4 Equations used to estimate intake resulting from the inhalation of particulates follow guidance given in Ref (26) for inhalation of airborne chemicals. For this route, it has been assumed that surficial soil chemical concentrations, intake rates, and atmospheric particulate concentrations remain constant over the exposure duration.

X2.6.5 Equations used to estimate intake resulting from the inhalation of airborne chemicals resulting from the volatilization of chemicals from surficial soils follow guidance given in Ref **(26)** for inhalation of airborne chemicals.

X2.6.6 A conceptual model for the volatilization of chemicals from surficial soils to outdoor air is depicted in Fig. X2.3. For simplicity, the relationship between outdoor air and surficial soil concentrations is represented in Tables X2.2 and X2.3 by the "volatilization factor" VF_{ss} [(mg/m^3-air)/(mg/kg-soil)] defined in Table X2.5. It is based on the following assumptions:

X2.6.6.1 Uniformly distributed chemical throughout the depth 0—*d* (cm) below ground surface,

X2.6.6.2 Linear equilibrium partitioning within the soil matrix between sorbed, dissolved, and vapor phases, where

TABLE X2.5 Volatilization Factors (VF_i), Leaching Factor (LF_{sw}), and Effective Diffusion Coefficients (D_i^{eff})

Symbol	Cross-Media Route (or Definition)	Equation
VF_{wesp}	Ground water → enclosed-space vapors	$VF_{wesp}\left[\frac{(mg/m^3\text{-}air)}{(mg/L\text{-}H_2O)}\right] = \dfrac{H\left[\dfrac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]}{1+\left[\dfrac{D_{ws}^{eff}/L_{GW}}{ER\,L_B}\right]+\left[\dfrac{D_{ws}^{eff}/L_{GW}}{(D_{crack}^{eff}/L_{crack})\eta}\right]} \times 10^3\ \frac{L}{m^3}$ [A]
VF_{wamb}	Ground water → ambient (outdoor) vapors	$VF_{wamb}\left[\frac{(mg/m^3\text{-}air)}{(mg/L\text{-}H_2O)}\right] = \dfrac{H}{1+\left[\dfrac{U_{air}\delta_{air}L_{GW}}{WD_{ws}^{eff}}\right]} \times 10^3\ \frac{L}{m^3}$ [B]
VF_{ss}	Surficial soils → ambient air (vapors)	$VF_{ss}\left[\frac{(mg/m^3\text{-}air)}{(mg/kg\text{-}soil)}\right] = \frac{2W\rho_s}{U_{air}\delta_{air}}\sqrt{\frac{D_s^{eff}H}{\pi[\theta_{ws}+k_s\rho_s+H\theta_{as}]\tau}} \times 10^3\ \frac{cm^3\text{-}kg}{m^3\text{-}g}$ [C] or: $VF_{ss}\left[\frac{(mg/m^3\text{-}air)}{(mg/kg\text{-}soil)}\right] = \frac{W\rho_s d}{U_{air}\delta_{air}\tau} \times 10^3\ \frac{cm^3\text{-}kg}{m^3\text{-}g}$; whichever is less [D]
VF_p	Surficial soils → ambient air (particulates)	$VF_p\left[\frac{(mg/m^3\text{-}air)}{(mg/kg\text{-}soil)}\right] = \frac{P_e W}{U_{air}\delta_{air}} \times 10^3\ \frac{cm^3\text{-}kg}{m^3\text{-}g}$ [E]
VF_{samb}	Subsurface soils → ambient air	$VF_{samb}\left[\frac{(mg/m^3\text{-}air)}{(mg/kg\text{-}soil)}\right] = \dfrac{H\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]\left(1+\dfrac{U_{air}\delta_{air}L_S}{D_s^{eff}W}\right)} \times 10^3\ \frac{cm^3\text{-}kg}{m^3\text{-}g}$ [F]
VF_{sesp}	Subsurface soil → enclosed-space vapors	$VF_{sesp}\left[\frac{(mg/m^3\text{-}air)}{(mg/kg\text{-}soil)}\right] = \dfrac{\dfrac{H\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]}\left[\dfrac{D_s^{eff}/L_S}{ER\,L_B}\right]}{1+\left[\dfrac{D_s^{eff}/L_S}{ER\,L_B}\right]+\left[\dfrac{D_s^{eff}/L_S}{(D_{crack}^{eff}/L_{crack})\eta}\right]} \times 10^3\ \frac{cm^3\text{-}kg}{m^3\text{-}g}$ [A]
LF_{sw}	Subsurface soils → ground water	$LF_{sw}\left[\frac{(mg/L\text{-}H_2O)}{(mg/kg\text{-}soil)}\right] = \dfrac{\rho_s}{[\theta_{ws}+k_s\rho_s+H\theta_{as}]\left(1+\dfrac{U_{gw}\delta_{gw}}{IW}\right)} \times 10^0\ \frac{cm^3\text{-}kg}{L\text{-}g}$ [B]
D_s^{eff}	Effective diffusion coefficient in soil based on vapor-phase concentration	$D_s^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$ [A]
D_{crack}^{eff}	Effective diffusion coefficient through foundation cracks	$D_{crack}^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{acrack}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcrack}^{3.33}}{\theta_T^2}$ [A]
D_{cap}^{eff}	Effective diffusion coefficient through capillary fringe	$D_{cap}^{eff}\left[\frac{cm^2}{s}\right] = D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2} + D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$ [A]
D_{ws}^{eff}	Effective diffusion coefficient between ground water and soil surface	$D_{ws}^{eff}\left[\frac{cm^2}{s}\right] = (h_{cap}+h_v)\left[\frac{h_{cap}}{D_{cap}^{eff}}+\frac{h_v}{D_s^{eff}}\right]^{-1}$ [A]
C_s^{sat}	Soil concentration at which dissolved pore-water and vapor phases become saturated	$C_s^{sat}\left[\frac{mg}{kg\text{-}soil}\right] = \frac{S}{\rho_s}\times[H\theta_{as}+\theta_{ws}+k_s\rho_s]\times 10^0\ \frac{L\text{-}g}{cm^3\text{-}kg}$ [F]

[A] See Ref (29).
[B] See Ref (30).
[C] See Ref (31).
[D] Based on mass balance.
[E] See Ref (32).
[F] See Ref (33).

TABLE X2.6 Soil, Building, Surface, and Subsurface Parameters Used in Generating Example Tier 1 RBSLs

NOTE—See X2.10 for justification of parameter selection.

Parameters	Definitions, Units	Residential	Commercial/Industrial
d	lower depth of surficial soil zone, cm	100 cm	100 cm
D^{air}	diffusion coefficient in air, cm^2/s	chemical-specific	chemical-specific
D^{wat}	diffusion coefficient in water, cm^2/s	chemical-specific	chemical-specific
ER	enclosed-space air exchange rate, L/s	0.00014 s^{-1}	0.00023 s^{-1}
f_{oc}	fraction of organic carbon in soil, g-C/g-soil	0.01	0.01
H	henry's law constant, (cm^3-H_2O)/(cm^3-air)	chemical-specific	chemical-specific
h_{cap}	thickness of capillary fringe, cm	5 cm	5 cm
h_v	thickness of vadose zone, cm	295 cm	295 cm
I	infiltration rate of water through soil, cm/years	30 cm/year	30 cm/year
k_{oc}	carbon-water sorption coefficient, cm^3-H_2O/g-C	chemical-specific	chemical-specific
k_s	soil-water sorption coefficient, cm^3-H_2O/g-soil	$f_{oc} \times k_{oc}$	$f_{oc} \times k_{oc}$
L_B	enclosed-space volume/infiltration area ratio, cm	200 cm	300 cm
L_{crack}	enclosed-space foundation or wall thickness, cm	15 cm	15 cm
L_{GW}	depth to ground water = $h_{cap} + h_v$, cm	300 cm	300 cm
L_S	depth to subsurface soil sources, cm	100 cm	100 cm
P_e	particulate emission rate, g/cm^2-s	6.9×10^{-14}	6.9×10^{-14}
S	pure component solubility in water, mg/L-H_2O	chemical-specific	chemical-specific
U_{air}	wind speed above ground surface in ambient mixing zone, cm/s	225 cm/s	225 cm/s
U_{gw}	ground water Darcy velocity, cm/year	2500 cm/year	2500 cm/year
W	width of source area parallel to wind, or ground water flow direction, cm	1500 cm	1500 cm
δ_{air}	ambient air mixing zone height, cm	200 cm	200 cm
δ_{gw}	ground water mixing zone thickness, cm	200 cm	200 cm
η	areal fraction of cracks in foundations/walls, cm^2-cracks/cm^2-total area	0.01 cm^2-cracks/cm^2-total area	0.01 cm^2-cracks/cm^2-total area
θ_{acap}	volumetric air content in capillary fringe soils, cm^3-air/cm^3-soil	0.038 cm^3-air/cm^3-soil	0.38 cm^3-air/cm^3-soil
θ_{acrack}	volumetric air content in foundation/wall cracks, cm^3-air/cm^3 total volume	0.26 cm^3-air/cm^3 total volume	0.26 cm^3-air/cm^3 total volume
θ_{as}	volumetric air content in vadose zone soils, cm^3-air/cm^3-soil	0.26 cm^3-air/cm^3-soil	0.26 cm^3-air/cm^3-soil
θ_T	total soil porosity, cm^3/cm^3-soil	0.38 cm^3/cm^3-soil	0.38 cm^3/cm^3-soil
θ_{wcap}	volumetric water content in capillary fringe soils, cm^3-H_2O/cm^3-soil	0.342 cm^3-H_2O/cm^3-soil	0.342 cm^3-H_2O/cm^3-soil
θ_{wcrack}	volumetric water content in foundation/wall cracks, cm^3-H_2O/cm^3 total volume	0.12 cm^3-H_2O/cm^3 total volume	0.12 cm^3-H_2O/cm^3 total volume
θ_{ws}	volumetric water content in vadose zone soils, cm^3-H_2O/cm^3-soil	0.12 cm^3-H_2O/cm^3-soil	0.12 cm^3-H_2O/cm^3-soil
ρ_s	soil bulk density, g-soil/cm^3-soil	1.7 g/cm^3	1.7 g/cm^3
τ	averaging time for vapor flux, s	7.88×10^8 s	7.88×10^8 s

the partitioning is a function of constant chemical- and soil-specific parameters,

X2.6.6.3 Diffusion through the vadose zone,

X2.6.6.4 No loss of chemical as it diffuses towards ground surface (that is, no biodegradation), and

X2.6.6.5 Steady well-mixed atmospheric dispersion of the emanating vapors within the breathing zone as modeled by a "box model" for air dispersion.

X2.6.7 In the event that the time-averaged flux exceeds that which would occur if all chemical initially present in the surficial soil zone volatilized during the exposure period, then the volatilization factor is determined from a mass balance assuming that all chemical initially present in the surficial soil zone volatilizes during the exposure period.

X2.7 *Subsurface Soils—Inhalation of Outdoor Vapors:*

X2.7.1 In this case chemical intake is a result of inhalation of outdoor vapors which originate from hydrocarbons contained in subsurface soils located some distance below ground surface. Here the goal is to determine the RBSL for subsurface soils that corresponds to the target RBSL for outdoor vapors in the breathing zone, as given in X2.2. If the selected target vapor concentration is some value other than

TABLE X2.7 Chemical-Specific Properties Used in the Derivation Example Tier 1 RBSLs

Chemical	CAS Number	M_w, g/mol	H, L-H_2O/L-air	D^{air}, cm^2/s	D^w, cm^2/s	log(K_{oc}), L/kg	log(K_{ow}), L/kg
Benzene	71-43-2	78[A]	0.22[A]	0.093[A]	1.1×10^{-5} [A]	1.58[A]	2.13[A]
Toluene	108-88-3	92[A]	0.26[A]	0.085[A]	9.4×10^{-6} [D]	2.13[A]	2.65[A]
Ethyl benzene	100-41-4	106[A]	0.32[A]	0.076[A]	8.5×10^{-6} [D]	1.98[A]	3.13[A]
Mixed xylenes	1330-20-7	106[A]	0.29[A]	0.072[D]	8.5×10^{-6} [D]	2.38[A]	3.26[A]
Naphthalene	91-20-3	128[A]	0.049[A]	0.072[D]	9.4×10^{-6} [A]	3.11[A]	3.28[A]
Benzo(a)pyrene	50-32-8	252[C]	5.8×10^{-8} [B]	0.050[D]	5.8×10^{-6} [D]	5.59[E]	5.98[B]

Chemical	CAS Number	SF_o, kg-day/mg	SF_i, kg-day/mg	RfD_o, mg/kg-day	RfD_i, mg/kg-day
Benzene	71-43-2	0.029[F]	0.029[F]	...	...
Toluene	108-88-3	...	...	0.2[F]	0.11[F]
Ethyl benzene	100-41-4	...	...	0.1[F]	0.29[F]
Mixed xylenes	1330-20-7	...	...	2.0[F]	2.0[F]
Naphthalene	91-20-3	...	...	0.004[G]	0.004[G]
Benzo(a)pyrene	50-32-8	7.3[F]	6.1[F]	...	...

[A] See Ref (34).
[B] See Ref (35).
[C] See Ref (7).
[D] Diffusion coefficient calculated using the method of Fuller, Schettler, and Giddings, from Ref (11).
[E] Calculated from K_{ow}/K_{oc} correlation: $\log(K_{oc}) = 0.937 \log(K_{ow}) - 0.006$, from Ref (11).
[F] See Ref (2).
[G] See Ref (3).

the RBSL for inhalation (that is, odor threshold or ecological criterion), this value can be substituted for the $RBSL_{air}$ parameter appearing in the equations given in Tables X2.2 and X2.3.

X2.7.2 A conceptual model for the transport of chemicals from subsurface soils to ambient air is depicted in Fig. X2.4. For simplicity, the relationship between outdoor air and soil concentrations is represented in Tables X2.2 and X2.3 by the "volatilization factor," VF_{samb} [(mg/m^3-air)/(kg-soil)], defined in Table X2.5. It is based on the following assumptions:

X2.7.2.1 A constant chemical concentration in subsurface soils,

X2.7.2.2 Linear equilibrium partitioning within the soil matrix between sorbed, dissolved, and vapor phases, where the partitioning is a function of constant chemical- and soil-specific parameters,

X2.7.2.3 Steady-state vapor- and liquid-phase diffusion through the vadose zone to ground surface,

X2.7.2.4 No loss of chemical as it diffuses towards ground surface (that is, no biodegradation), and

X2.7.2.5 Steady well-mixed atmospheric dispersion of the emanating vapors within the breathing zone as modeled by a "box model" for air dispersion.

X2.7.3 Should the calculated $RBSL_s$ exceed the value for which the equilibrated vapor and dissolved pore-water phases become saturated, C_s^{sat} [mg/kg-soil] (see Table X2.5 for calculation of this value), "RES" is entered in the table to indicate that the selected risk level or hazard quotient cannot be reached or exceeded for that compound and the specified exposure scenario (even if free-phase product or precipitate is present in the soil).

X2.8 *Subsurface Soils—Inhalation of Enclosed-Space (Indoor) Vapors:*

X2.8.1 In this case chemical intake is a result of inhalation of enclosed-space vapors which originate from hydrocarbons contained in subsurface soils located some distance below ground surface. Here the goal is to determine the RBSL for subsurface soils that corresponds to the target RBSL for indoor vapors, as given in Tables X2.2 and X2.3. If the selected target vapor concentration is some value other than the RBSL for inhalation (that is, odor threshold or

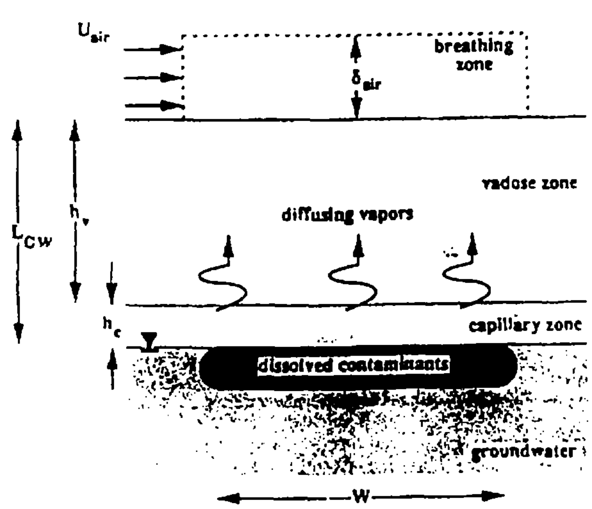

FIG. X2.1 Volatilization from Ground Water to Ambient Air

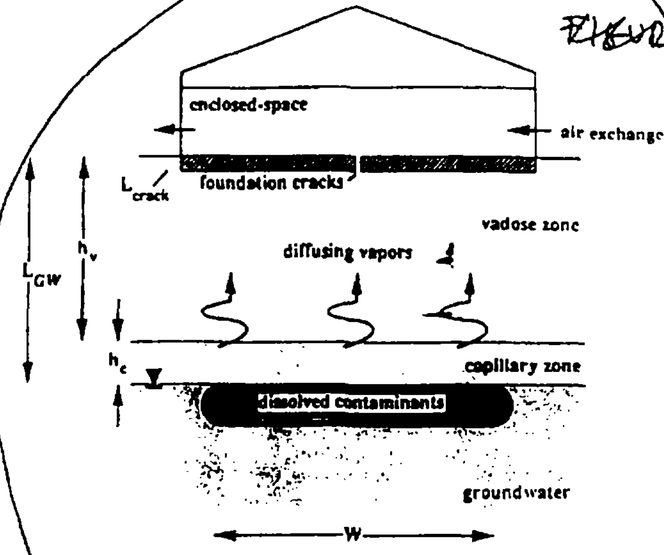

FIG. X2.2 Volatilization from Ground Water to Enclosed-Space Air

ecological criterion), this value can be substituted for the $RBSL_{air}$ parameter appearing in the equations given in Tables X2.2 and X2.3.

X2.8.2 A conceptual model for the transport of chemicals from subsurface soils to enclosed spaces is depicted in Fig. X2.5. For simplicity, the relationship between indoor air and soil concentrations is represented in Tables X2.2 and X2.3 by the "volatilization factor," VF_{sesp} [(mg/m^3-air)/(kg-soil)], defined in Table X2.5. It is based on the following assumptions:

X2.8.2.1 A constant chemical concentration in subsurface soils,

X2.8.2.2 Linear equilibrium partitioning within the soil matrix between sorbed, dissolved, and vapor phases, where the partitioning is a function of constant chemical- and soil-specific parameters,

X2.8.2.3 Steady-state vapor- and liquid-phase diffusion through the vadose zone and foundation cracks,

X2.8.2.4 No loss of chemical as it diffuses towards ground surface (that is, no biodegradation), and

X2.8.2.5 Well-mixed atmospheric dispersion of the emanating vapors within the enclosed space.

X2.8.3 Should the calculated $RBSL_s$ exceed the value C_s^{sat} [mg/kg-soil] for which the equilibrated vapor and dissolved pore-water phases become saturated (see Table X2.5 for calculation of this value), "RES" is entered in the table to indicate that the selected risk level or hazard

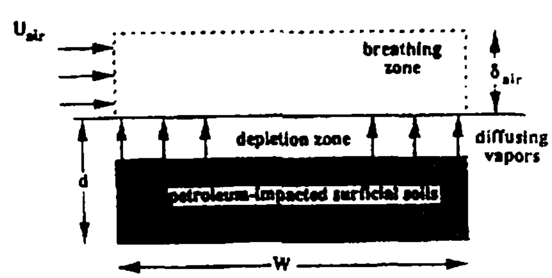

FIG. X2.3 Volatilization from Surficial Soils

ATTACHMENT B
CALCULATION WORKSHEETS

CALCULATION OF SITE-SPECIFIC GROUNDWATER SCREENING LEVEL FOR ENCLOSED-SPACE VAPORS PROTECTION

Private Residence
Vicinity of Lockformer Facility
Lisle, Illinois

Chemical Compound: Trichloroethylene

INPUT PARAMETERS

Scenario-Specific Parameters

Parameter	Value	Units	Description	Source
Scenario	Residential	-	Scenario Type	-
TR	1E-06	unitless	Target Cancer Risk	ASTM
BW	70	(kg)	Adult Body Weight	ASTM
ATc	70	(years)	Averaging Time for Carcinogens	ASTM
IRair-indoor	15	(m3/d)	Daily Indoor Inhalation Rate	ASTM
EF	350	(d/yr)	Exposure Frequency	ASTM
ED	30	(yr)	Exposure Duration	ASTM

Compound-Specific Parameters

Parameter	Value	Units	Description	Source
Compound	Trichloroethylene	-	Name of Chemical Compound	-
SFi	4.00E-01	(mg/kg-d)-1	Inhalation Cancer Slope Factor	IEPA
H'	0.42	(unitless)	Henry's Law constant	TACO
Dair	0.079	(cm2/s)	Diffusion Coefficient in Air	TACO
Dwater	9.1E-06	(cm2/s)	Diffusion Coefficient in Water	TACO

Site-Specific Parameters

Parameter	Value	Units	Description	Source
nl	0.01	(unitless)	Areal Fraction of Cracks in Foundations/Walls	ASTM
ER	0.00014	(s-1)	Enclosed-Space Air Exchange Rate	ASTM
Lgw	1525	(cm)	Depth to Groundwater	S
Lb	200	(cm)	Enclosed-Space Volume/Infiltration Area Ratio	ASTM
Lcrack	15	(cm)	Enclosed-Space Foundation or Wall Thickness	ASTM
hcap	152	(cm)	Thickness of Capillary Fringe	S
hv	1373	(cm)	Thickness of Vadose Zone	S
nws	0.12	(unitless)	Volumetric Water Content in Vadose Zone Soils	ASTM
nas	0.26	(unitless)	Volumetric Air Content in Vadose Zone Soils	ASTM
n	0.38	(unitless)	Total Soil Porosity	ASTM
nwcap	0.38	(unitless)	Volumetric Water Content in Capillary Fringe Soils	S
nacap	0	(unitless)	Volumetric Air Content in Capillary Fringe Soils	S
nwcrack	0.12	(unitless)	Volumetric Water Content in Foundation/Wall Cracks	ASTM
nacrack	0.26	(unitless)	Volumetric Air Content in Foundation/Wall Cracks	ASTM

S	Site Specific Parameter
ASTM	ASTM Standard E 1739-95
TACO	Table E, Default Physical/Chemical Parameters, Part 742, June 1998
IEPA	Value provided by the IEPA
Eq	Value calculated by previous equation

CALCULATION OF SITE-SPECIFIC GROUNDWATER SCREENING LEVEL FOR ENCLOSED-SPACE VAPORS PROTECTION

Private Residence
Vicinity of Lockformer Facility
Lisle, Illinois

Chemical Compound: Trichloroethylene

CALCULATED PARAMETERS

Effective Diffusion Coefficient in Soil Based on Vapor-Phase Concentration (Ds-eff)

Input Parameters	Value	Units	Description	Source
Dair	0.079	(cm2/s)	Diffusion Coefficient in Air	TACO
Dwater	9.10E-06	(cm2/s)	Diffusion Coefficient in Water	TACO
H'	0.422	(unitless)	Henry's Law constant	TACO
nws	0.12	(unitless)	Volumetric Water Content in Vadose Zone Soils	ASTM
nas	0.26	(unitless)	Volumetric Air Content in Vadose Zone Soils	ASTM
n	0.38	(unitless)	Total Soil Porosity	ASTM
Calculated Parameter	**Value**	**Units**	**Description**	**Source**
Ds-eff	**6.14E-03**	**(cm2/s)**	**Effective Diffusion Coefficient in Soil**	**Eq.**

Effective Diffusion Coefficient through Foundation Cracks (Dcrack-eff)

Input Parameters	Value	Units	Description	Source
Dair	0.079	(cm2/s)	Diffusion Coefficient in Air	TACO
Dwater	9.100000000E-06	(cm2/s)	Diffusion Coefficient in Water	TACO
H'	0.422	(unitless)	Henry's Law constant	TACO
nwcrack	0.12	(unitless)	Volumetric Water Content in Foundation/Wall Cracks	ASTM
nacrack	0.26	(unitless)	Volumetric Air Content in Foundation/Wall Cracks	ASTM
n	0.38	(unitless)	Total Soil Porosity	ASTM
Calculated Parameter	**Value**	**Units**	**Description**	**Source**
Dcrack-eff	**6.14E-03**	**(cm2/s)**	**Effective Diffusion Coefficient through Foundation Cracks**	**Eq.**

Effective Diffusion Coefficient through Capillary Fringe (Dcap-eff)

Input Parameters	Value	Units	Description	Source
Dair	0.079	(cm2/s)	Diffusion Coefficient in Air	TACO
Dwater	9.10E-06	(cm2/s)	Diffusion Coefficient in Water	TACO
H'	0.422	(unitless)	Henry's Law constant	TACO
nwcap	0.38	(unitless)	Volumetric Water Content in Capillary Fringe Soils	S
nacap	0	(unitless)	Volumetric Air Content in Capillary Fringe Soils	S
n	0.38	(unitless)	Total Soil Porosity	ASTM
Calculated Parameter	**Value**	**Units**	**Description**	**Source**
Dcap-eff	**5.94E-06**	**(cm2/s)**	**Effective Diffusion Coefficient through Capillary Fringe**	**Eq.**

S	Site Specific Parameter
ASTM	ASTM Standard E 1739-95
TACO	Table E, Default Physical/Chemical Parameters, Part 742, June 1998
IEPA	Value provided by the IEPA
Eq	Value calculated by previous equation

CALCULATION OF SITE-SPECIFIC GROUNDWATER SCREENING LEVEL FOR ENCLOSED-SPACE VAPORS PROTECTION

Private Residence
Vicinity of Lockformer Facility
Lisle, Illinois

Chemical Compound: Trichloroethylene

CALCULATED PARAMETERS

Effective Diffusion Coefficient between Groundwater and Soil Surface (Dws-eff)

Input Parameters	Value	Units	Description	Source
hcap	152.4	(cm)	Thickness of Capillary Fringe	S
hv	1372.6	(cm)	Thickness of Vadose Zone	S
Dcap-eff	5.94E-06	(cm2/s)	Effective Diffusion Coefficient through Capillary Fringe	Eq
Ds-eff	6.14E-03	(cm2/s)	Effective Diffusion Coefficient in Soil	Eq.

Calculated Parameter	Value	Units	Description	Source
Dws-eff	**5.89E-05**	**(cm2/s)**	**Effective Diffusion Coefficient between Groundwater and Soil Surface**	Eq.

Groundwater - Enclosed Space Vapors Volatilization Factor (VFwesp)

Input Parameters	Value	Units	Description	Source
H'	0.422	(unitless)	Henry's Law constant	TACO
Dws-eff	5.89E-05	(cm2/s)	Effective Diffusion Coefficient between Groundwater and Soil Surface	Eq.
Lgw	1525	(cm)	Depth to Groundwater	S
ER	0.00014	(s-1)	Enclosed-Space Air Exchange Rate	ASTM
Lb	200	(cm)	Enclosed-Space Volume/Infiltration Area Ratio	ASTM
Dcrack-eff	6.14E-03	(cm2/s)	Effective Diffusion Coefficient through Foundation Cracks	Eq.
Lcrack	15	(cm)	Enclosed-Space Foundation or Wall Thickness	ASTM
ni	0.01	(unitless)	Areal Fraction of Cracks in Foundations/Walls	ASTM

Calculated Parameter	Value	Units	Description	Source
VFwesp	**5.77E-04**	**(mg/m3)/(mg/L)**	**Groundwater - Enclosed Space Vapors Volatilization Factor**	Eq.

Risk-Based Screening Level for Inhalation (RBSLair)

Input Parameters	Value	Units	Description	Source
TR	1E-06	unitless	Target Cancer Risk	ASTM
BW	70	(kg)	Adult Body Weight	ASTM
ATc	70	(years)	Averaging Time for Carcinogens	ASTM
IRair-indoor	15	(m3/d)	Daily Indoor Inhalation Rate	ASTM
EF	350	(d/yr)	Exposure Frequency	ASTM
ED	30	(yr)	Exposure Duration	ASTM
SFi	0.4	(mg/kg-d)-1	Inhalation Cancer Slope Factor	IEPA

Calculated Parameter	Value	Units	Description	Source
RBSLair	**2.84E-02**	**(ug/m3)**	**Risk-Based Screening Level for Inhalation**	Eq.

S	Site Specific Parameter
ASTM	ASTM Standard E 1739-95
TACO	*Table E. Default Physical/Chemical Parameters, Part 742, June 1998*
IEPA	Value provided by the IEPA
Eq	Value calculated by previous equation

CALCULATION OF SITE-SPECIFIC GROUNDWATER SCREENING LEVEL FOR ENCLOSED-SPACE VAPORS PROTECTION

Private Residence
Vicinity of Lockformer Facility
Lisle, Illinois

Chemical Compound: Trichloroethylene

CALCULATED PARAMETERS				
Risk-Based Screening Level for Enclosed-Space Vapor Inhalation (RBSLw)				
Input Parameters	**Value**	**Units**	**Description**	**Source**
RBSLair	2.84E-02	(ug/m3)	Risk-Based Screening Level for Inhalation	Eq.
VFwesp	5.77E-04	(mg/m3)/(mg/L)	Groundwater - Enclosed Space Vapors Volatilization Factor	Eq.
Calculated Parameter	**Value**	**Units**	**Description**	**Source**
RBSLw	**4.92E-02**	**(mg/L)**	**Risk-Based Screening Level for Enclosed-Space Vapor Inhalation**	Eq.

S	*Site Specific Parameter*
ASTM	ASTM Standard E 1739-95
TACO	Table E, Default Physical/Chemical Parameters, Part 742, June 1998
IEPA	Value provided by the IEPA
Eq	Value calculated by previous equation